Working Memory Can Explain Antisaccade Failures Without Inhibition

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Introduction

Claims about inhibitory processes in the prefrontal cortex are generally supported by evidence of inhibitory failures. Such failures are considered to occur when a highly prepotent action – one with a high prior probability of being appropriate – is selected instead of a more contextually appropriate, goal-directed response. Patterns of inhibitory failure are most often reported in human subjects with frontal lobe damage, in human infants and young children, and in normal subjects under cognitive load (or distraction). We argue that in many of these cases, a simpler account of the data would characterize the system at fault as a working memory system, and not as an inhibitory module per se.

Anti-Saccades

In the antisaccade task (Guitton, Buchtel, and Douglas, 1985), subjects are required to respond to a visually presented cue by looking not at the cue itself, but to a location on the opposite side of a fixation point.

Guitton, Buchtel, and Douglas (1985) first reported that frontal-damaged patients have trouble with this task, hypothesizing a frontal lobe role in aborting inappropriate behaviors. Roberts, Hager, and Heron (1994) found that a working memory load caused both slower reaction times and more errors in the antisaccade task, while leaving reflexive pro-saccades unaffected. They described an interaction in which working memory allows one to maintain and use information to be used in inhibiting highly prepotent responses.

Modeling Antisaccade Failures

We propose that working memory and inhibitory processes are not independently necessary to explain this type of data. Since a working memory system should contain all the information necessary to determine the correct response, it is unnecessary to postulate an independent process of inhibiting the prepotent response, except in the implicit sense that the two responses are in competition.

Our model of antisaccade failures is implemented within the framework used by Kimberg and Farah (1993) to simulate other data from patients with prefrontal damage. Within this framework, we characterize the processes that produce behavior in terms of response discrimination. Two sources of activation (of the four included in the model) are especially important to this task:

Baseline strength reflects the long-term history of a response's use. Responses that have been more useful in the past will generally tend to be activated to a higher level. **Working memory activation** reflects the contribution of relevant declarative representations, such as might be created by giving the subject instructions.

The simulation of the anti-saccade task is extremely simple. Two potential responses compete for activation: **look-towards** and **look-away**. **Look-towards** has a much higher baseline strength. However, a declarative representation of the anti-saccade instructions also provides activation to **look-away**. Normally this representation is only weakly activated. However, when the subject has been given the instructions to perform the anti-saccade task, it is maintained at a higher level of activation.

Since it is only the contribution from working memory that allows the system to override the strong bias in favor of looking towards stimuli, any form of weakening working memory will disproportionately affect the antisaccade task. A memory load (as in Roberts et al., 1994) may be simulated by reducing by a constant factor the activations of all working memory representations. We can also simulate the effect of prefrontal damage, as in our previous model, by weakening associations among working memory elements. Either manipulation has the effect of weakening the effect of instructions in favor of the prepotent response – an apparent disinhibition without damage to an inhibitory module.

References

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